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2020-11

Merikanto , I & Partonen , T 2020 , ' Increase in eveningness and insufficient sleep among adults in population-based cross-sections from 2007 to 2017 ' , Sleep Medicine , vol. 75 , pp. 368-379 . https://doi.org/10.1016/j.sleep.2020.07.046

http://hdl.handle.net/10138/334427
https://doi.org/10.1016/j.sleep.2020.07.046

Increase in eveningness and insufficient sleep among adults in population-based cross-sections from 2007 to 2017

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Declarations of interest: none.

Funding:

This study was funded by The Academy of Finland (projects 322312), Juho Vainio Foundation and Alfred Kordelin Foundation. The funders had no role in study design, data collection and interpretation, or the decision to submit the work for publication. There are no competing financial interests.

Abstract

Objectives: Short or long sleep duration, insufficient sleep, and Evening chronotype associate with many health issues and increased risk for mortality. Understanding population-level changes in sleep and chronotype frequencies is important for assessing the prospective health status of the society and future challenges on health care at a national level. This study examines the cross-sectional differences in sleep duration, insufficient sleep, and chronotype frequencies indicated by both circadian preference and habitual sleep-wake rhythm among adults living in Finland during a 10-year period of 2007 to 2017.

Methods: The study sample (N=18,039) was derived from The National FINRISK 2007 and 2012 Studies, and The FinHealth 2017 Study, each consisting of a random sample of adults, aged 25 to 74 years and as stratified by age and sex, and providing the self-reported data on their circadian preference, habitual daily sleep duration, insufficient sleep and bedtimes.

Results: During the 10 years, sleep duration decreased, insufficient sleep increased and circadian preference towards eveningness increased significantly in each 10-year age group and among both sexes. In general, eveningness was more common among younger adults in all the study years but, as compared to 2012, in 2017 bedtimes and midpoint of sleep were more advanced among this age group while sleep-wake rhythm became more delayed in older adults. The decrease in sleep duration and the increase in insufficient sleep were emphasized in younger adults and especially in women, whereas the increase in eveningness in older adults and in men.

Conclusions: The evolution of sleep and chronotype frequencies from 2007 to 2017 is alarming, as these might lead to a poorer health status in the adult population and thus cause more strain to the public health. The mismatch between sleep-wake behavior and circadian preference was emphasized in young adults, indicating a greater risk for circadian misalignment in the Finnish adult population in the future, if there will not be any interventions to correct this mismatch.

Keywords: Bedtime; Chronotype; Midsleep; Morningness-eveningness; Sleep duration; Social jetlag

1. Introduction

The average of 7 to 8 or 9 hours of sleep per night is recommend for adults as habitual sleep duration shorter or longer than this been associated with many health issues, such as cardiovascular diseases, metabolic disorders, impaired cognition [1–7]. Decreases in sleep duration have been observed at national level in Finland since the 1970s to 2005 [8], as well as in some other countries [9], but sleep duration trajectories at population level during the 21st century are known less in detail.

Sleep-wake behavior and many other daily behaviors and physiological functions follow circadian rhythmicity in their timing that shows individual variation. This variation is seen among people as a difference in circadian preference either more towards eveningness or morningness [10–12]. Increasing number of epidemiological studies have associated circadian preference for eveningness with multiple health hazards, such as sleep problems, increased risk for poor mental health and diseases ranging from metabolic, cardiovascular, respiratory and spinal disorders as well as with shorter life expectancy [13–19]. Habitual midpoint of sleep is another commonly used chronotype indicator [20]. Although these chronotype indicators have shown to correlate strongly [21], they are not mutually exclusive but complementary in describing the individual chronotype differently. Habitual midpoint of sleep, as compared to circadian preference, reflects the actualized sleep-wake behavior that can be time sensitive and more influenced by factors other than innate circadian tendencies such as societal schedules. Circadian preference, on the other hand, is considered to be rather consistent trait during adulthood [22] and describes what a person feels as their optimal behavioral timing based on the daily changes in their innate vigor. Mismatch between the habitual sleep-wake rhythm and circadian preference and between sleep-wake schedules on weekdays and weekends can predispose to desynchronizing of the intrinsic circadian rhythms [23], which has serious health consequences [24]. Thus, information on circadian preference frequencies, habitual sleep timing behavior and projections on their change at a population level is important for assessing sleep and circadian rhythms related health prospective and the health care demands at a national level. However, research on differences in circadian preference across time at a population level is thus far lacking.

Populations worldwide are changing in demographical [25], societal and behavioral aspects [26,27] and these changes are likely to influence also sleep behavior and circadian preference frequencies. For instance, the prevalence rate distribution for circadian preferences differ by age, eveningness being more common among younger people and peaking during late adolescence and early adulthood, but morningness being more common in among older people [18,28,29]. Changes in population age-structure can thus also affect circadian preference frequencies. As life expectancies have improved, many populations are moving towards an age-structure of more elderly people. For instance, the population in Finland is having one of the highest increase of the EU countries in adults aged 65 years or older from 2008 to 2018, 21.4% of the population meeting this age in 2018 [30]. In Finland, many changes in work life, time allocation and social behavior [31] have occurred that could affect sleep and circadian preference. For instance, flexible working hours and remote work have become more common [32], which can promote circadian preference towards eveningness. Also, the evening use of electronic devices has become popular across all ages [26]. The inner clock is entrained by environmental clues of the solar cycle, mostly by lighting conditions [33]. The increased evening or night-time use of electronic media devices stimulates wakefulness through bright light exposure and may shorten sleep and delay circadian rhythms [34,35].

Accordingly, this study examined the differences in circadian preference frequencies as well as those in the self-reported habitual sleep-wake rhythm, sleep duration and insufficient sleep in the Finnish adult population, aged 25 to 74 years, at three cross-sections at the years of

2007, 2012 and 2017. The distribution in circadian preference and sleep was examined by 10-year age groups and in addition also separately in women and men across time. Finally, we also assessed the mismatch between sleep-wake rhythm and circadian preference type in the Finnish adult population.

2. Methods

2.1 Participants

The data in this study were derived from three population-based health examination surveys on Finnish adults, namely The National FINRISK 2007 Study, The National FINRISK 2012 Study, and The FinHealth 2017 Study. These studies consisted of random samples of 10,000 adults aged 25 to 74 years in 2007 and 2012 and a random sample of adults aged 18 years or older without any upper limit in 2017 as stratified by sex and 10-year age groups from five large geographical areas in Finland. More detailed descriptions of The National FINRISK 2007 and 2012 Studies are provided in our previous report [36]. For the purpose of this study, we selected from The FinHealth 2017 Study only the participants of the similar age-range to match with the previous population-based datasets, i.e., those aged 25 to 74 years, in order to accurately compare any differences in chronotype distribution and sleep at the population level. A total of 6520 participants from The National FINRISK 2007 Study, 6305 participants from The National FINRISK 2012 Study and 5214 participants from The FinHealth 2017 Study had information on the self-assessed morningness/eveningness. A total of 6129 and 5689 participants from The National FINRISK 2007 Study, 5879 and 5878 participants from The National FINRISK 2012 Study and 5393 and 5738 participants from The FinHealth 2017 Study had information on the self-assessed insufficient sleep and daily sleep duration respectively. Based on information from Statistics Finland, there were 3 334 117 Finnish citizens in 2007, 3 421 945 Finnish citizens in 2012 and 3 497 099 Finnish citizens in 2017 of age of 25-74 years. Thus, in each crosssection, the samples covered about 0.3% and caught about 0.02% of those aged 25 to 74 years living in Finland.

The mean age between the samples differed approximately by a year in maximum (mean age=50.67 years, SD=13.99, in 2007; mean age=51.02 years, SD=14.09, in 2012; mean age=52.12 years, SD=13.80, in 2017). The 10-year age group frequencies from 2007 to 2017 are shown in Table 1. The sex distribution differed between the samples by 1 to 3 percent-points, women being the more common sex throughout (Table 1).

The National FINRISK 2007 and 2012 Studies and The FinHealth 2017 Study were approved by the Coordinating Ethics Committee of the Hospital District of Helsinki and Uusimaa, Finland. They were conducted according to accepted international ethical standards in accordance with the Declaration of Helsinki and its amendments. All the participants gave written informed consent.

2.2 Chronotype measurements

Circadian preference was assessed in all the study samples by MEQ item 19 from the Horne-Östberg Morningness-Eveningness Questionnaire (MEQ) [12]. This question requests individuals to estimate their circadian preference as either “Definitely a ‘morning’ person”, “More a ‘morning’ than an ‘evening’ person”, “More an ‘evening’ than a ‘morning’ person”, or “Definitely an ‘evening’ person”. This single item was used in this study to indicate the morningness/eveningness in optimal behavioral timing.

Habitual sleep-wake rhythm was assessed by average bedtimes and midpoint of sleep separately for weekdays and weekends. The midpoint of sleep was calculated based on self-reported bedtimes and wake up times in The National FINRISK 2012 Study and The FinHealth 2017 Study to indicate general sleep timing. Midpoint of sleep was determined by the half of the time passed in sleep since going to bed in local time separately for weekdays and weekends [20].

2.3 Sleep duration and insufficient sleep

The usual daily sleep duration was self-reported in all the datasets in hours. Insufficient sleep was assessed on the basis of the self-estimation of either getting enough sleep nearly always, often, or rarely/never as reported in all three datasets.

2.4 Social jet lag

Social jet lag was determined to indicate the average mismatch between social and biological rhythm as the difference between the average weekend and weekday midpoint of sleep in hours and minutes [23].

2.5 Statistical analyses

Population-level differences in the frequencies of age, sex, circadian preference types and insufficient sleep were analyzed with chi-square tests and continuous sleep measurements with one-way analysis of variance (ANOVA). These analyses were also calculated separately for each 10-year age group and sex (women and men), as there are age and sex related differences in sleep and circadian preference in the Finnish adult population as reported of The National FINRISK 2007 Study [18]. Finally, we used generalized linear models (GZM), adjusted with age and sex, to analyze the associations between circadian preference and daily sleep duration (linear GZM), insufficient sleep (ordinal logistic GZM) and social jet lag (linear GZM) at different time points. Definite morning-types were set as the reference group in all these GZM. All the analyses were conducted with IBM SPSS Statistics 25 software.

3. Results

3.1 Differences in sleep duration and insufficient sleep in the Finnish adult population across time

As shown in Table 2, from 2007 to 2017, the daily sleep duration decreased significantly among each 10-year age group by 21 to 34 minutes, especially among the youngest 10-year age group (all p<0.0001). In the earlier 5-year period, from 2007 to 2012, the mean daily sleep duration decreased significantly, by 12 minutes, only among those aged 25 to 34 years (p=0.002), but not among other 10-year age groups (p≥0.40). However, in the later 5-year period, from 2012 to 2017, the daily sleep duration decreased significantly in each 10-year age group by 18 to 29 minutes, especially among the oldest age group (all p<0.0001). Men and women differed in their daily sleep duration by men having shorter sleep durations than women throughout the 10-year period of 2007 to 2017 (p<0.05). Table A.1 shows the daily sleep durations by sex from 2007 to 2007.

The self-assessed insufficient sleep, as reported rarely or hardly ever getting enough sleep, increased by 3 percent-points from the frequency of 15% in 2007 to that of 18% in 2017 (p<0.0001). The increase prevalence of self-assessed insufficient sleep was significant for those aged 35 years or older in each 10-year age group from 2012 to 2017 (p≤0.004) as well as in each 10-year age group when differences across time were examined across 10-year period (p≤0.03; see Table 2). Insufficient sleep increased from 2007 to 2017 most among those aged 35 to 44 years by 6 percent-points and among those aged 25 to 34 years by 5 percent-points. From 2007 to 2017, women reported more often than men not getting enough sleep: In 2007, 17% of women and 14% of men felt that they slept rarely or hardly ever enough (p<0.0001 between sexes). There were statistically no significant differences across time in these frequencies in neither sex from 2007 to 2012, but in 2017, 19% of women and 16% of men felt that they slept rarely or hardly ever enough (p=0.008 between sexes). Table A.1 shows the frequencies of the self-assessed insufficient sleep from 2007 to 2017 by 10-year age group among women and men separately.

3.2 Differences in habitual sleep-wake rhythm across time

As Table 3 shows, average bedtimes were advanced by 10 minutes on weekdays (p=0.003) and by 14 minutes on weekends (p=0.0004) in 5 years from 2012 to 2017 among those aged 25 to 34 years. For those aged 65 to 74 years, average bedtimes were on the other hand delayed on weekends (p=0.003) from 2012 to 2017. As shown in Table A.2, both of these findings were emphasized especially among women.

Among those aged 25 to 34 years, the weekday midpoint of sleep was advanced by 12 minutes (p=0.03) and the weekend midpoint of sleep by 22 minutes (p=0.002) from 2012 to 2017 (Table 3). On the other hand, among those aged 65 to 74 years, the weekday midpoint of sleep was delayed by 9 minutes (p=0.01) and the weekend midpoint of sleep by 7 minutes (p=0.02) across the same period. As shown in Table A.2, these findings were emphasized among women.

3.3 Differences in circadian preference frequencies across time

As illustrated in Figure 1, the circadian preference towards morningness as compared to eveningness was more common in the adult Finnish population especially in 2007, while a progressive decrease in Morning-oriented types was seen from 2007 to 2017. The self-assessed eveningness increased significantly among the Finnish adult population from 2007 to 2012 (p<0.0001). There were no statistically significant differences in the self-assessed morningness/eveningness frequencies from 2012 to 2017 (p=0.41).

The circadian preference type frequencies differed between men and women only in 2012 (p=0.01, for 2007 and 2017 p≥0.72). As illustrated in Figure 2, in 2012 men self-assessed themselves more frequently as more evening-oriented as compared to women. On the other hand, women self-assessed themselves more frequently than men as the definite evening-types, or as definite morning-types as well. Overall, as illustrated in in Figure 2, within the 5 years from 2007 to 2012, the frequencies of the eveningness increased both among men (p<0.0001) and women (p<0.0001). The increase in eveningness was somewhat emphasized in men as compared to women

(8.4 percent points as compared to 6.5 percent points difference between 2007 and 2012). There were no statistically significant differences in circadian preference type frequencies from 2012 to 2017 ($p=0.23$ in men, and $p=0.29$ in women).

Throughout 2007 to 2014, the frequency of definite evening-types and evening-oriented types were highest among the aged 25 to 34 years and morningness gradually emphasized in older age groups (Table 4. A similar tendency was seen also when women and men were analyzed separately (Table A.3).

The differences between the years 2007 and 2012 in the frequencies of circadian preference types were significant for each age group ($p \leq 0.006$), after which these frequencies remained similar from 2012 to 2017 ($p \geq 0.09$; see Table 4). The frequency of the definite evening-types increased in 10 years, from 2007 to 2017, in each age group ($p \leq 0.03$). The biggest difference in the frequency of the definite evening-types occurred among those aged 35 to 44 years from 2007 to 2017. For the age groups of 45 years or older, the frequency of more evening-oriented was progressively higher with older age groups in 2017 as compared to 2007. Higher frequency of definite evening-types and more evening-oriented in 2017 and 2012 as compared to 2007 was apparent among both sexes, in women for all ages and in men for ages 35 and above (Table A.3).

3.5 Daily sleep duration, insufficient sleep and social jet lag by circadian preference

As shown in Table 5, in 2007 the definite evening-types ($p=0.04$) and more evening than morning oriented participants ($p=0.02$) had both significantly longer daily sleep durations, by average 8 minutes, as compared to the definite morning-types. In 2012, circadian preference types did not statistically differ in their sleep duration (all $p \geq 0.13$). In 2017, all the other circadian preference types had statistically longer sleep durations than the definite morning-types: the definite evening-types by 8 minutes ($p=0.004$), more evening than morning oriented persons by 10 minutes ($p=0.00005$), more morning than evening oriented persons by 10 minutes ($p=0.00004$).

The self-reported insufficient sleep was more common in all the other self-assessed circadian preference types, as compared to the definite morning-types, in 2007 as well as in 2012. In 2007, the greatest insufficient sleep was reported by the definite evening-types ($p<0.0001$), followed progressively by those being more evening than morning oriented persons ($p<0.0001$) and those being more morning than evening oriented persons ($p<0.0001$). A similar tendency was seen also in 2012, with the greatest insufficient sleep being reported by the definite evening-types as compared to the definite morning-types ($p<0.0001$), followed progressively by those being more evening than morning oriented persons ($p<0.0001$) and by those being more morning than evening oriented persons ($p<0.0001$). In 2017, both the definite evening-types ($p<0.0001$) and those being more evening than morning oriented persons ($p<0.0001$) had more self-reported insufficient sleep than the definite morning-types, but those being more morning than evening oriented persons did not significantly differ from the definite morning-types in their self-reported insufficient sleep ($p=0.18$). From 2007 to 2017, the self-reported insufficient sleep increased among the definite morning-types and decreased among the definite evening-types (Figure 3).

Social jet lag was more common in all the other self-assessed circadian preference types, as compared to the definite morning-types, in 2012 as well as in 2017. In 2012, social jet lag was greatest among the definite evening-types ($p<0.0001$), followed progressively by those more evening than morning oriented persons ($p<0.0001$) and by those more morning than evening oriented persons ($p<0.0001$). A similar tendency was seen also in 2017, with the greatest insufficient sleep being reported by the definite evening-types as compared to the definite morning-types ($p<0.0001$), followed progressively by those more evening than morning oriented persons ($p<0.0001$) and those more morning than evening oriented persons ($p<0.0001$). Social jet lag decreased among the self-assessed circadian preference types, except the definite morning-types from 2012 to 2017 (Figure 4).

4. Discussion

The findings of this population-based study indicate significant cross-sectional differences in sleep behavior and circadian preferences in the general Finnish adult population from 2007 to 2017. During the 10-year study period, sleep duration decreased, insufficient sleep increased and circadian preference towards eveningness increased in each 10-year age groups of 25 to 74 years and in both sexes. As eveningness [13,15,17], insufficient sleep [7] and habitual sleep deviating from 7 to 8 hours per night [2,4,5] are associated with, or may predispose to, many health problems in adults, it is alarming that these have become more common in Finnish adult population across time.

4.1 Differences in sleep behavior across time

The decrease in daily sleep duration was emphasized among the younger adults, aged 25 to 34 years. Previous study on sleep behavior of Finnish adults indicates that the decrease in average sleep duration is seen already since the 1970s, but from 1972 to 2005 the decrease in sleep duration was only minor, about 6 minutes per 10 years, and emphasized among adults older than 30 years [8]. Similar trends in decreasing sleep duration since the 1960s to the 2000s have been reported in Japan, Russia, Germany, Belgium, and Austria [9]. According to the findings of this study, the trend in decreasing sleep duration among Finnish adults has speeded during the 21st century, decreasing by 21 to 34 minutes during the 10-year study period, and has become more prominent at a younger age. Accordingly, the feeling of not getting enough sleep was emphasized here among adults younger than 45 years.

Furthermore, from 2012 to 2017, the average bedtimes and midpoint of sleep on both weekdays and at weekends were advanced among those aged 25 to 34 years, while these were delayed among those aged 65 to 74 years. Thus, among the younger adults sleep schedules have become more earlier-timed along with a shorter daily sleep duration, which was felt as inadequate by 24% of those aged 25 to 34 years and by 27% of those aged 35 to 44 years in 2017. Among the elderly adults, later-timed sleep rhythm was more common, sleep duration was shorter and insufficient sleep more common in 2017 as compared to 2007.

4.2 Differences in circadian preferences across time

Overall, in line with previous studies [18,29], eveningness was throughout the 10-year period more common among the younger adult age groups, while circadian preference towards morningness was more common among the older adult age groups. However, eveningness increased among the Finnish adult population during the study period. The increase in the self-reported definite eveningness was significant for all age groups, but emphasized among those aged 35 to 44 years. Furthermore, concerning those aged older than 44 years there was a progressive increase in the proportion of more evening-oriented persons during the 10-year period. The increase in eveningness in the Finnish adult population can itself explain the increase in reporting insufficient sleep among adults, as eveningness associates with sleep problems, such as insomnia symptoms and insufficient sleep [18].

4.3 Societal and behavioral changes in Finland

Only speculation on the reasons for the observed sleep and circadian preference differences in Finnish adult population across time can be made based on our findings. One possibility is that the differences across time in sleep relate to the differences seen in circadian preference frequencies from 2007 to 2017. These differences across time could arise because of, e.g., changes in time allocation and behavior affecting sleep-wake schedules, or changes in mental well-being as depression and stress often associate with poor sleep [37,38] and are more common among Evening-types than among other chronotypes [36,39]. To be noted, the increase in eveningness was emphasized from 2007 to 2012 and not so much from 2012 to 2017. This would indicate that the effects promoting eveningness presented themselves especially after between 2007 and 2012. The

Finnish Working Life Barometer 2013 and 2018 reveals that the recession in Finland in 2008 created economic pressures that since then led to job losses and increase in unemployment rate [32]. This has created more competition in gaining and keeping jobs along with increased workloads, which could have negative impacts on sleep and circadian alignment [40,41].

Young adulthood is a time-period sensitive to sleep problems, as there is incentive for early sleep-wake schedules due to pressures from building a work career [41] and parenting responsibilities [42,43]. This can result to sleep problems when falling asleep does not occur at the wanted time. The mismatch between societally preferred schedules and biological schedules can be estimated with calculating social jet lag [44]. In line with the assumption that social jet lag is emphasized in Evening-types [44] and that the sleep need might be greater for Evening-types due to differences in circadian period length between chronotypes [45,46], our findings showed that eveningness was associated with longer sleep duration, greater insufficient sleep and social jet lag as compared to the self-reported morningness. Together with the findings on the increase of eveningness in all age groups and in both sexes from 2007 to 2017, these results indicate that the risk for the mismatch between sleep-wake behavior and circadian preference and for the possible circadian disruption has become more common in the Finnish adult population. Based on the results presented in this study, it seems that the risk for circadian disruption is emphasized among the young adults, because eveningness remained most common circadian preference type among this age group even though bedtimes and midpoint of sleep were advanced among them. The higher mismatch between sleep-wake schedule and circadian preference can also explain why sleep duration decreased and the feeling of insufficient sleep increased especially among young adults.

An interesting finding in our study indicates eveningness becoming more common across time especially among the older age groups. In a Finnish report on household time-use, screen time had increased while social behavior decreased from 2000 to 2010 among Finnish men and women, and especially and progressively among those aged 45 to 64 years as well as those aged 65 years or older [31]. This could also relate to decrease in sleep duration and the increase in eveningness especially among the older adults. In Finland, the use of smart phones and tablets became popular among adults of all ages after 2013 [47]. In 2013, 55% of the Finnish people had a smartphone, but this number has increased by average 5 percent-points per year and the screen time on smartphone among those aged 65 years or older is becoming more common all the time [47–49]. Another explanation for the increased eveningness, besides the increased late evening screen time and isolation among elderly, could be that Evening-types reach higher age than they did before. It could be speculated that the life expectancy in Evening-types is lower than in other chronotypes, because a range of health issues accumulate to Evening-types in Finnish adult cohorts [15–17,36]. Also, in a UK Biobank study the self-assessed eveningness was associated with higher mortality than morningness [14].

4.4 Differences in sleep and circadian preference between sexes across time

Even though men slept less than women throughout the 10-year study period, women reported more often than men not getting enough sleep. This findings could relate to eveningness being more common among women as compared to men in Finnish adults, and eveningness has indeed been associated with insufficient sleep in Finnish adults [18]. Furthermore, the advance in average weekend and weekday bedtimes among the younger adults was emphasized among women as compared to men, suggesting that women could be more vulnerable to social jet lag. Also, the delay in weekend and weekday bedtimes among the older adults was emphasized among women. It is possible that women try to advance their circadian preference to adjust more to the social and work schedules when they are still at a working age and possibly having small or school-aged children, but this comes at the cost in sufficient sleep.

Across the 10-year study period, the circadian preference towards eveningness became more common in both sexes. The definite eveningness increased especially in men aged 35 to 44 years (by 11 percent-points). In women, the increase in definite eveningness was emphasized among young adults (by 8 percent-points).

In a recent meta-analysis which was based on 164 studies using circadian preference questionnaires for the assessment of circadian preference, men were on average more evening-oriented than women, but this was dependent on age, as younger women were more morning-orientated than younger men, but older women were less morning-orientated than older men [50]. In contrast, concerning the Finnish adult population, women tend to be more evening-oriented than men in all adult age groups, as far as the circadian preference is assessed with the 6-item MEQ [18]. When circadian preference was assessed with the single question in this study, young men aged 25 to 34 years perceived themselves more often as definite evening-types (23.3% to 29.7% in the three different datasets) or evening-oriented (38.5% to 42.0% in the three different datasets) than young women (16.7% to 24.6% and 36.4% to 40.2% respectively in the three different datasets). From the age of 35 years onwards, women assessed themselves more often than men as either definite or more evening-types than men in all age groups. Young men thus seem to consider themselves to be more evening-oriented than women during young adulthood, which is in line with the findings in the meta-analysis [50], even though in Finland eveningness is more pronounced among women.

4.5 Strengths and limitations

Strengths of this current study include the random samples of the adult population, which were stratified by age and gender. Another strength are the unique datasets, which were derived from three population-based health examination surveys, covering a period of 10 years in a high-income country with extensive welfare systems. Thus, the data we used for analysis were likely not subject to selection or bias in the population under study.

There are however some limitations to not having all the information available for all datasets. The information on weekday and weekend bedtimes and wake-up times, on the other hand, were not available on 2007 and thus midpoint of sleep and social jet lag could be calculated only in 2012 and 2017 datasets. There was no objective data on circadian rhythms or sleep schedules, but all the data were based on self-reports and collected at cross-sections.

4.6 Conclusions

The findings of this study show a decrease in sleep duration along with increase in eveningness and insufficient sleep among each 10-year age group of 25 to 74 years old Finnish adults and among both women and men from 2007 to 2017. The decrease in sleep duration and the increase in insufficient sleep as well as in eveningness are alarming, since they may lead to a poorer prospective of health status and thereof the public health. The findings of this study also indicate that the mismatch between sleep-wake behavior and circadian preference was emphasized in young adults. Unless interventions are made to reduce the mismatch between an individual's biological circadian rhythm and the actualized sleep-wake and behavioral rhythm, the risk for future health problems due to circadian misalignment or circadian disruption at an adult population level will most likely arise. The behavioral models provided by adults also influence children and adolescents, as they easily imitate and follow the example set not only by their parents, but also by adults at large. For instance, the use of electronic devices and social media in the evening hours has increased among all generations at the expense of sleep, which is likely to promote the behavioral trait of eveningness. More emphasis should be given on prioritizing sleep and more attention should be paid to healthy life habits at a societal level.

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Figure legends

Figure 1. Distribution of the circadian preference types in the Finnish adult population in 2007, 2012, and 2017 as measured in percent-points.

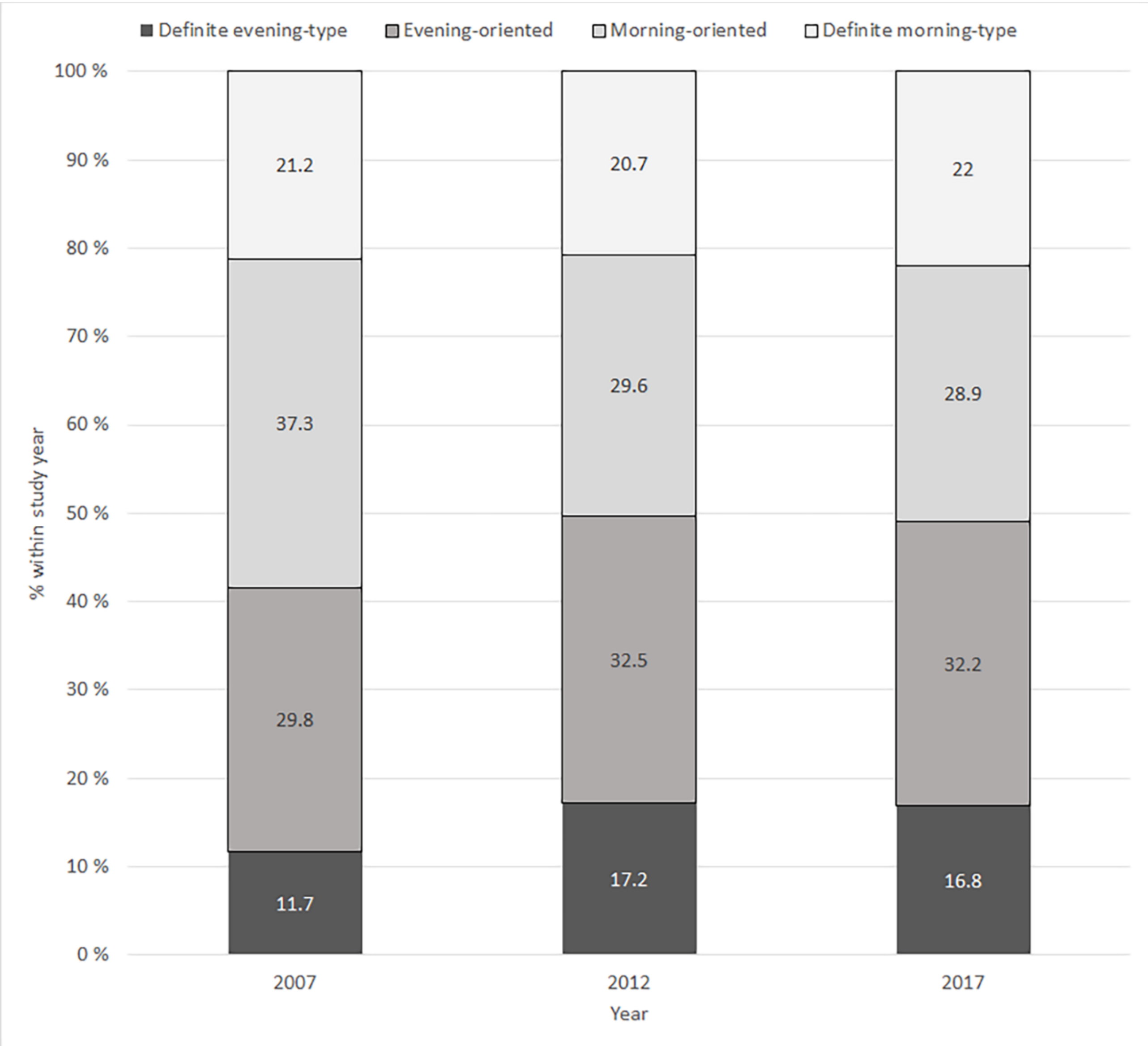

Figure 2. Distribution of the circadian preference types in the Finnish adult population in 2007, 2012, and 2017 as measured in percent-points separately in men and women.

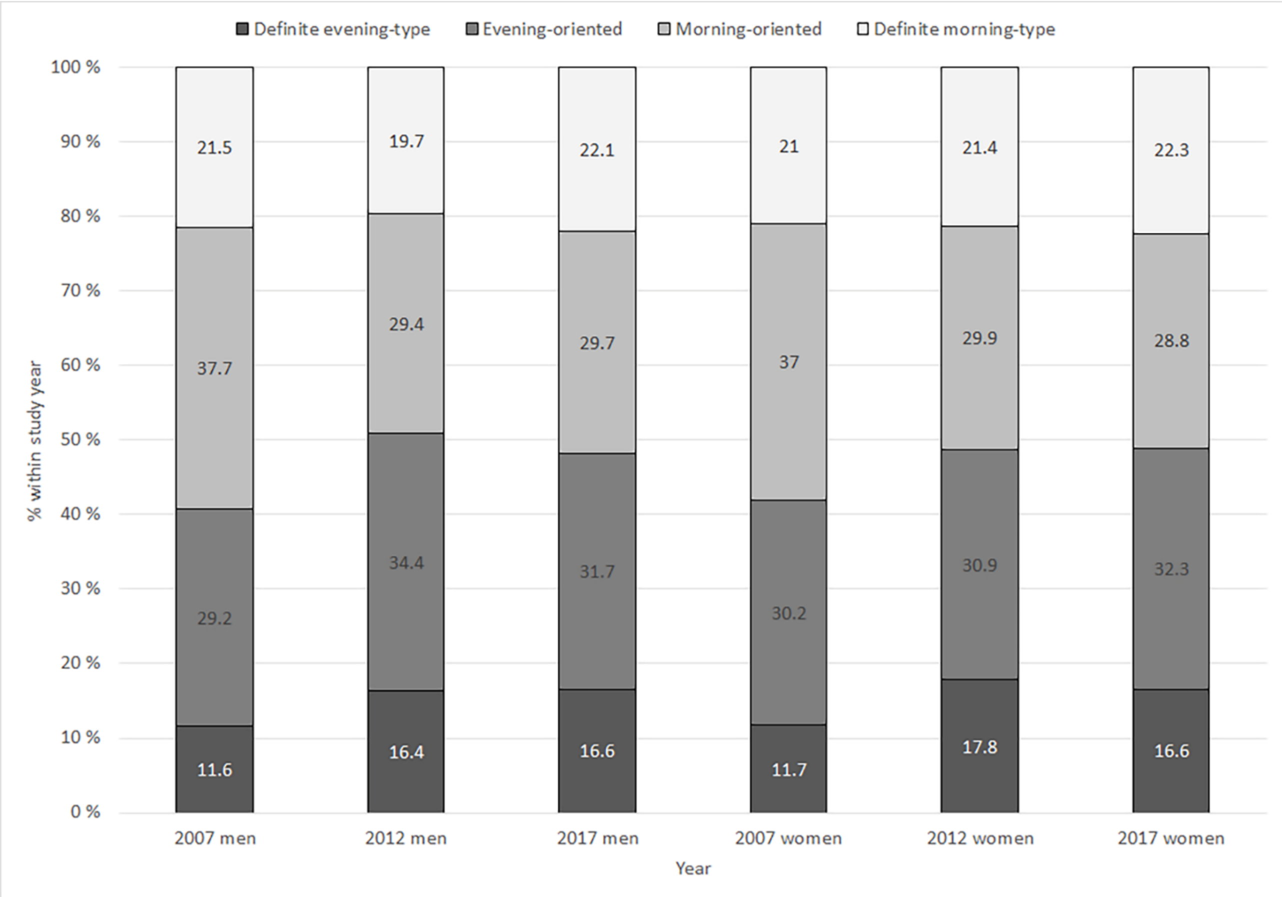

Figure 3. Insufficient sleep within the self-assessed morningness/eveningness from 2007 to 2017 indicated as the percentage reporting getting rarely or hardly ever enough sleep.

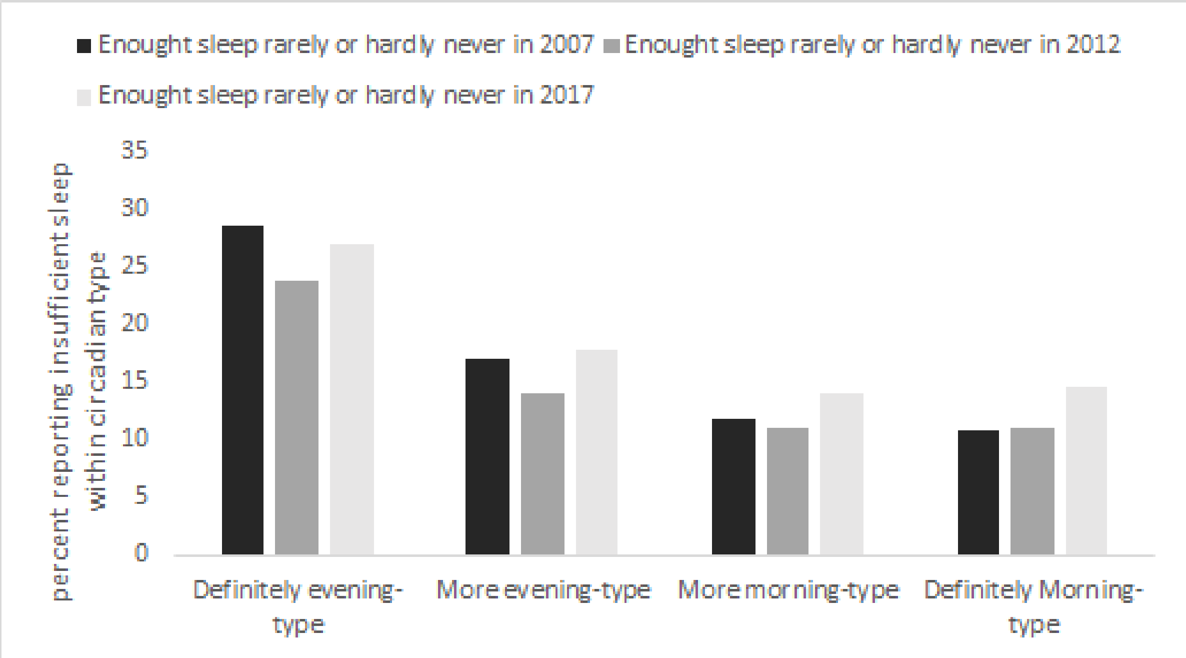

Figure 4. Social jet lag in seconds by the self-assessed morningness/eveningness in years 2012 and 2017.

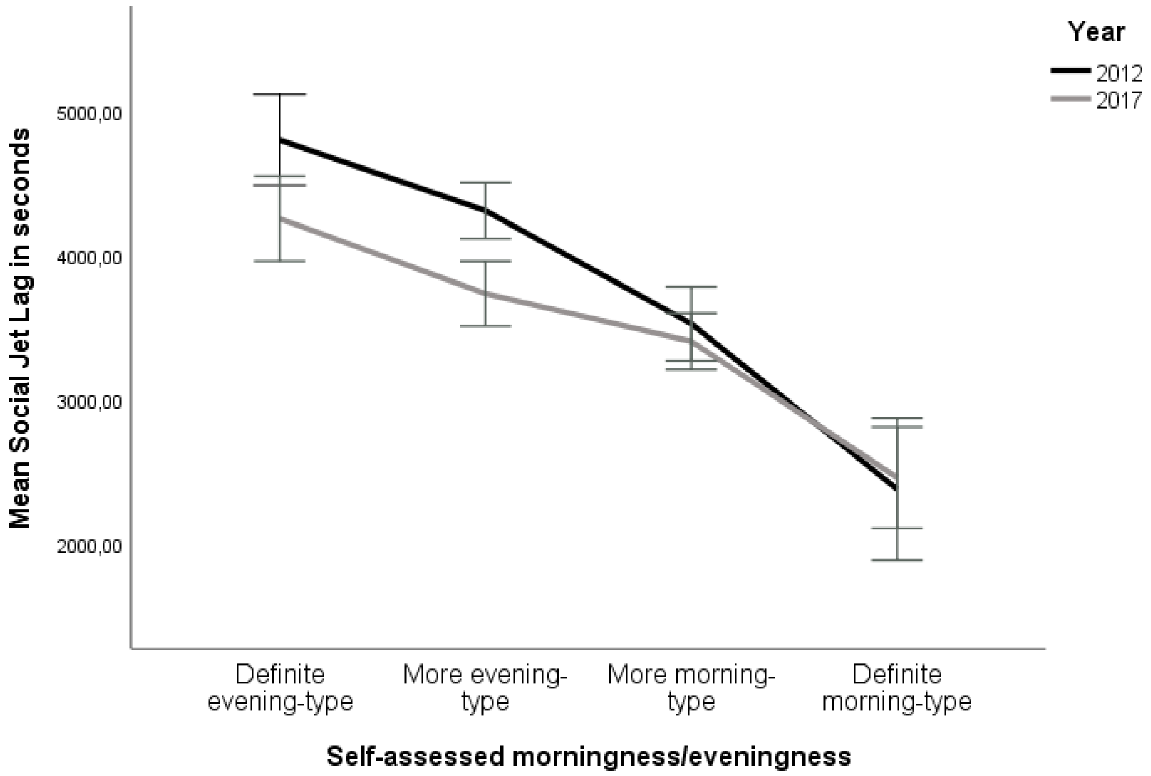

Table 1. Age and sex structures of the cross-sectional samples on participants with information on circadian preference.

	2007 (N=6520)	2012 (N=6305)	2017 (N=5214)	
10-year age groups, %				p=0.0005
Ages 25 to 34	16.5	16.3	14.8	
Ages 35 to 44	19.0	18.8	17.4	
Ages 45 to 54	20.7	20.1	19.1	
Ages 55 to 64	21.7	21.6	24.2	
Ages 65 to 74	22.1	23.1	24.6	
Sex, %				p=0.002
Women	53.6	52.7	55.9	
Men	46.4	47.3	44.1	

Table 2. Daily mean sleep duration and the self-assessed insufficient sleep by age group from 2007 to 2017 in the Finnish adult population.

	Daily mean sleep duration				
	2007 (N=5689)	2012 (N=5878)		2017 (N=5738)		
	Mean hh:mm (SD)	Mean hh:mm (SD)	p-value [a]	Mean hh:mm (SD)	p-value [b]	p-value [c]
Ages 25 to 34	7:49 (1:23)	7:37 (1:20)	0.002	7:15 (1:17)	<0.0001	<0.0001
Ages 35 to 44	7:31 (1:15)	7:32 (1:26)	0.67	7:10 (0:55)	<0.0001	<0.0001
Ages 45 to 54	7:27 (1:16)	7:27 (1:25)	0.90	7:05(1:00)	<0.0001	<0.0001
Ages 55 to 64	7:34 (1:16)	7:31 (1:28)	0.40	7:13 (1:09)	<0.0001	<0.0001
Ages 65 to 74	7:49(1:30)	7:47 (1:31)	0.67	7:18 (1:12)	<0.0001	<0.0001

	Self-assessed insufficient sleep											
	2007 (N=6129)			2012 (N=5879)				2017 (N=5393)				
	Enough sleep nearly always, % (N)	Enough sleep often, % (N)	Enough sleep rarely or hardly never, % (N)	Enough sleep nearly always, % (N)	Enough sleep often, % (N)	Enough sleep rarely or hardly never, % (N)	p-value [a]	Enough sleep nearly always, % (N)	Enough sleep often, % (N)	Enough sleep rarely or hardly never, % (N)	p-value [b]	p-value [c]
Ages 25 to 34	26.4 (272)	55.0 (567)	18.6 (192)	25.6 (248)	54.5 (528)	19.9 (193)	0.75	22.4 (199)	53.6 (476)	24.0 (213)	0.06	0.008
Ages 35 to 44	28.8 (340)	50.5 (596)	20.7 (245)	30.1 (329)	52.2 (571)	17.7 (194)	0.19	18.5 (181)	54.9 (537)	26.7 (261)	<0.0001	<0.0001
Ages 45 to 54	33.0 (415)	49.0 (615)	18.0 (226)	32.5 (391)	52.1 (626)	15.4 (185)	0.16	28.2 (301)	51.6 (552)	20.2 (216)	0.004	0.03
Ages 55 to 64	45.1 (598)	42.8 (568)	12.1 (160)	44.8 (570)	41.3 (525)	13.9(177)	0.35	38.1 (484)	46.3 (589)	15.6 (198)	0.003	0.0005
Ages 65 to 74	60.4 (806)	31.8 (424)	7.9 (105)	62.0 (832)	31.3 (420)	6.7 (90)	0.46	51.1 (606)	38.7 (459)	10.2 (121)	<0.0001	<0.0001

Statistical difference by one-way ANOVA and chi-square. SD refers to standard deviation. [a] statistical difference between 2007 and 2012; [b] statistical difference between 2012 and 2017; [c] statistical difference between 2007 and 2017.

Table 3. Mean bedtimes and midpoint of sleep on weekdays and weekends by age group in 2012 and 2017. Statistical difference by one-way ANOVA. SD refers to standard deviation.

	Weekday bedtimes in hours:min			Weekend bedtimes in hours:min		
	2012	2017		2012	2017	
	Mean (SD)	Mean (SD)	p-value	Mean (SD)	Mean (SD)	p-value
Ages 25 to 34	22:53 (1:14)	22:43 (1:11)	0.003	0:00 (1:20)	23:46 (1:15)	0.0004
Ages 35 to 44	22:38 (1:14)	22:39 (1:09)	0.79	23:29 (1:10)	23:30 (1:07)	0.84
Ages 45 to 54	22:29 (1:06)	22:31 (1:07)	0.60	23:17 (1:08)	23:20 (1:08)	0.29
Ages 55 to 64	22:29 (1:09)	22:25 (1:00)	0.15	23:02 (1:16)	23:06 (1:07)	0.12
Ages 65 to 74	22:32 (1:01)	22:35 (0:59)	0.26	22:45 (1:03)	22:53 (1:03)	0.003
	Weekday midpoint of sleep in hours:min			**Weekend midpoint of sleep in hours:min**		
	2012	**2017**		**2012**	**2017**	
	Mean (SD)	**Mean (SD)**	**p-value**	**Mean (SD)**	**Mean (SD)**	**p-value**
Ages 25 to 34	3:04 (1:48)	2:52 (1:25)	0.03	4:35 (1:16)	4:23 (1:14)	0.002
Ages 35 to 44	2:46 (2:02)	2:46 (1:39)	0.93	4:00 (1:06)	4:00 (1:03)	0.95
Ages 45 to 54	2:30 (1:27)	2:30 (1:14)	0.96	3:46 (1:08)	3:50 (1:15)	0.22
Ages 55 to 64	2:34 (1:28)	2:33 (1:20)	0.79	3:30 (1:21)	3:32 (1:02)	0.52
Ages 65 to 74	2:52 (1:14)	3:01 (1:33)	0.01	3:12 (1:16)	3:19 (1:17)	0.02

Table 4. Distribution of the circadian preference types in the Finnish adult population from 2007 to 2017 by 10-year age group.

	2007 (N=6520)								2012 (N=6305)									2017 (N=5214)									
	Definetely evening-type		More evening-type		More morning-type		Definetely Morning-type		Definetely evening-type		More evening-type		More morning-type		Definetely Morning-type		p-value [a]	Definetely evening-type		More evening-type		More morning-type		Definetely Morning-type		p-value [b]	p-value [c]
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%		N	%	N	%	N	%	N	%		
Ages 25 to 34	211	19.5	436	40.2	335	30.9	102	9.4	274	26.7	417	40.6	254	24.7	83	8.1	0.0002	172	25.4	253	37.3	189	27.9	64	9.4	0.28	0.03
Ages 35 to 44	170	13.7	436	35.2	454	36.6	180	14.5	250	21.2	407	34.5	338	28.7	184	15.6	<0.0001	177	22.7	270	34.6	214	27.4	119	15.3	0.86	<0.0001
Ages 45 to 54	142	10.6	406	30.2	491	36.5	305	22.7	190	14.9	390	30.6	418	32.8	278	21.8	0.006	125	14	294	32.9	254	28.4	221	24.7	0.09	0.0004
Ages 55 to 64	124	8.8	351	24.8	581	41.0	361	25.5	186	13.7	412	30.3	402	29.5	361	26.5	<0.0001	137	12.1	343	30.4	353	31.2	297	26.3	0.63	<0.0001
Ages 65 to 74	113	7.9	317	22.1	573	39.9	432	30.1	183	12.5	423	29.0	457	31.3	398	27.2	<0.0001	156	14.5	310	28.7	310	28.7	303	28.1	0.36	<0.0001

[a] Chi-square between morningness/eveningness frequencies in 2007 and 2012; [b] Chi-square between morningness/eveningness frequencies in 2012 and 2017; [c] Chi-square between morningness/eveningness frequencies in 2007 and 2017.

Table 5. Average daily sleep duration, insufficient sleep and social jet lag by the circadian preference in generalized linear models, adjusted with age and sex, and definite morning-types as the reference group.

	Definite evening-type					More evening-type					More morning-type				
	average hh:mm	B	95% CI		p-value	average hh:mm	B	95% CI		p-value	average hh:mm	B	95% CI		p-value
			Lower	Upper				Lower	Upper				Lower	Upper	
2007															
Daily mean sleep duration	7:42	0.13	0.001	0.26	0.04	7:41	0.12	0.02	0.23	0.02	7:36	0.05	-0.05	0.15	0.33
Insufficient sleep		1.18	0.99	1.36	<0.0001		0.68	0.54	0.82	<0.0001		0.40	0.26	0.53	<0.0001
2012															
Daily mean sleep duration	7:36	0.08	-0.05	0.20	0.22	7:37	0.08	-0.02	0.19	0.13	7:35	0.05	0.16	0.77	0.38
Insufficient sleep		0.94	0.78	1.11	<0.0001		0.52	0.38	0.66	<0.0001		0.31	0.17	0.45	<0.0001
Social jet lag	1:20	2418.62	1916.99	2910.26	<0.0001	1:12	1940.33	1507.62	2373.04	<0.0001	0:59	1146.05	705.92	1586.19	<0.0001
2017															
Daily mean sleep duration	7:16	0.14	0.04	0.24	0.004	7:17	0.17	0.09	0.26	<0.0001	7:17	0.18	0.09	0.26	<0.0001
Insufficient sleep		0.70	0.51	0.89	<0.0001		0.42	0.26	0.57	<0.0001		0.11	-0.05	0.27	0.18
Social jet lag	1:11	1714.72	1255.63	2173.81	<0.0001	1:02	1280.91	890.66	1671.16	<0.0001	0:57	943.48	545.10	1341.86	<0.0001

B=estimated coefficient, CI=Confidence Intervals

Table A.1. Daily mean sleep length and insufficient sleep by sex and age group from 2007 to 2017 in the Finnish adult population.

	Daily mean sleep duration					
	MEN					
	2007 (N=2710) Mean (SD)	**2012 (N=2809) Mean (SD)**	**p-value [a]**	**2017 (N=2724) Mean (SD)**	**p-value [b]**	**p-value [c]**
Ages 25 to 34	7:40 (1:28)	7:25 (1:22)	0.007	7:08 (0:54)	0.001	<0.0001
Ages 35 to 44	7:20 (1:15)	7:22 (1:32)	0.60	7:00 (0:55)	<0.0001	<0.0001
Ages 45 to 54	7:20 (1:21)	7:21 (1:27)	0.82	6:59 (0:69)	<0.0001	<0.0001
Ages 55 to 64	7:38 (1:17)	7:31 (1:28)	0.11	7:11 (1:09)	<0.0001	<0.0001
Ages 65 to 74	7:55 (1:28)	7:56 (1:21)	0.72	7:20 (1:11)	<0.0001	<0.0001
	WOMEN					
	2007 (N=2979) Mean (SD)	**2012 (N=3069) Mean (SD)**	**p-value [a]**	**2017 (N=3014) Mean (SD)**	**p-value [b]**	**p-value [c]**
Ages 25 to 34	7:55 (1:19)	7.46 (1:17)	0.09	7:20 (1:04)	<0.0001	<0.0001
Ages 35 to 44	7:40 (1:14)	7:40 (1:20)	0.95	7:19 (0:54)	<0.0001	<0.0001
Ages 45 to 54	7:34 (1:10)	7:32 (1:23)	0.70	7:11 (1:01)	<0.0001	<0.0001
Ages 55 to 64	7:30 (1:09)	7:32 (1:27)	0.67	7:15 (1:07)	<0.0001	0.0001
Ages 65 to 74	7:42 (1:31)	7:37 (1:41)	0.33	7:16 (1:29)	<0.0001	<0.0001

	Self-assessed insufficient sleep											
	MEN											
	2007 (N=6129)			**2012 (N=5879)**				**2017 (N=2561)**				
	Enough sleep nearly always, % (N)	**Enough sleep often, % (N)**	**Enough sleep rarely or hardly never, % (N)**	**Enough sleep nearly always, % (N)**	**Enough sleep often, % (N)**	**Enough sleep rarely or hardly never, % (N)**	**p-value [a]**	**Enough sleep nearly always, % (N)**	**Enough sleep often, % (N)**	**Enough sleep rarely or hardly never, % (N)**	**p-value [b]**	**p-value [c]**
Ages 25 to 34	28.0 (120)	54.4 (233)	17.5 (75)	24.9 (103)	56.2 (232)	18.9 (78)	0.58	22.3 (90)	56.9 (230)	20.8 (84)	0.60	0.13
Ages 35 to 44	29.2 (156)	52.2 (279)	18.5 (99)	33.4 (165)	50.0 (247)	16.6 (82)	0.33	14.9 (68)	59.6 (272)	25.4 (116)	<0.0001	<0.0001
Ages 45 to 54	34.4 (198)	47.4 (273)	18.2 (105)	31.6 (177)	53.2 (298)	15.2 (85)	0.13	26.9 (135)	52.7 (264)	20.4 (102)	0.05	0.03
Ages 55 to 64	46.9 (309)	42.8 (282)	10.3 (68)	47.1 (288)	40.7 (2499	12.3 (75)	0.50	39.7 (252)	46.0 (292)	14.3 (919	0.03	0.01
Ages 65 to 74	64.5 (430)	29.5 (197)	6.0 (40)	66.4 (457)	29.1 (200)	4.5 (31)	0.44	55.6 (314)	36.3 (205)	8.1 (46)	0.0002	0.006
	WOMEN											
	2007 (N=3265)			**2012 (N=3112)**				**2017 (N=2832)**				
	Enough sleep nearly always, % (N)	**Enough sleep often, % (N)**	**Enough sleep rarely or hardly never, % (N)**	**Enough sleep nearly always, % (N)**	**Enough sleep often, % (N)**	**Enough sleep rarely or hardly never, % (N)**	**p-value [a]**	**Enough sleep nearly always, % (N)**	**Enough sleep often, % (N)**	**Enough sleep rarely or hardly never, % (N)**	**p-value [b]**	**p-value [c]**
Ages 25 to 34	25.2 (152)	55.4 (334)	19.4 (117)	26.1 (145)	53.2 (296)	20.7 (115)	0.75	22.5 (109)	50.8 (246)	26.7 (129)	0.06	0.02
Ages 35 to 44	28.4 (184)	49.0 (317)	22.6 (146)	27.3 (164)	54.0 (324)	18.7 (112)	0.14	21.6)113)	50.7 (265)	27.7 (145)	0.001	0.01
Ages 45 to 54	31.9 (217)	50.3 (342)	17.8 (121)	33.3 (214)	51.1 (328)	15.6 (100)	0.54	29.2 (166)	50.7 (288)	20.1 (114)	0.08	0.45
Ages 55 to 64	43.3 (289)	42.9 (286)	13.8 (92)	42.7 (282)	41.8 (276)	15.5 (102)	0.69	36.5 (323)	46.7 (297)	16.8 (107)	0.07	0.03
Ages 65 to 74	56.3 (376)	34.0 (227)	9.7 (65)	57.3 (375)	33.6 (220)	9.0 (59)	0.88	47.0 (292)	40.9 (254)	12.1 (75)	0.001	0.01

Statistical difference by one-way ANOVA and chi-square. SD refers to standard deviation. [a] statistical difference between 2007 and 2012; [b] statistical difference between 2012 and 2017; [c] statistical difference between 2007 and 2017.

Table A.2. Mean bedtimes and the midpoint of sleep on weekdays and weekends by 10-year age group and sex in 2012 and 2017. Statistical difference by one-way ANOVA. SD refers to standard deviation.

	MEN						**WOMEN**					
	Weekday bedtimes in hours:min			**Weekend bedtimes in hours:min**			**Weekday bedtimes in hours:min**			**Weekend bedtimes in hours:min**		
	2012	**2017**		**2012**	**2017**		**2012**	**2017**		**2012**	**2017**	
	Mean (SD)	**Mean (SD)**	**p-value**	**Mean (SD)**	**Mean (SD)**	**p-value**	**Mean (SD)**	**Mean (SD)**	**p-value**	**Mean (SD)**	**Mean (SD)**	**p-value**
Ages 25 to 34	23:06 (1:21)	22:58 (1:17)	0.14	0:15 (1:23)	0:02 (1:21)	0.04	22:44 (1:07)	22:32 (1:03)	0.007	23:48 (1:16)	23:34 81:09)	0.002
Ages 35 to 44	22:50 (1:24)	22:54 (1:11)	0.53	23:41 (1:15)	23:47 (1:12)	0.23	22:27 (1:03)	22:26 (1:05)	0.93	23:20 (1:03)	23:17 (0:59)	0.42
Ages 45 to 54	22:37 (1:01)	22:38 (1:15)	0.92	23:26 (1:09)	23:24 (1:15)	0.67	22:22 (1:09)	22:25 (1:00)	0.43	23:08 (1:05)	23:16 (1:02)	0.03
Ages 55 to 64	22:32 (1:08)	22:26 (1:00)	0.14	23:03 (1:19)	23:07 (1:13)	0.37	22:27 (1:10)	22:24 (1:00)	0.55	23:01 (1:14)	23:06 (1:02)	0.19
Ages 65 to 74	22:36 (1:07)	22:37 (1:01)	0.65	22:48 (1:07)	22:54 (1:04)	0.09	22:28 (0:54)	22:33 (0.57)	0.18	22:43 (0:58)	22:52 (1:01)	0.008
	Weekday midpoint of sleep in hours:min			**Weekend midpoint of sleep in hours:min**			**Weekday midpoint of sleep in hours:min**			**Weekend midpoint of sleep in hours:min**		
	2012	**2017**		**2012**	**2017**		**2012**	**2017**		**2012**	**2017**	
	Mean (SD)	**Mean (SD)**	**p-value**	**Mean (SD)**	**Mean (SD)**	**p-value**	**Mean (SD)**	**Mean (SD)**	**p-value**	**Mean (SD)**	**Mean (SD)**	**p-value**
Ages 25 to 34	3:10 (1:56)	2:58 /1:17)	0.15	4:46 (1:19)	4:41 (1:19)	0.06	2:59 (1:41)	2:48 (1:30)	0.09	4:27 (1:14)	4:22 (1:12)	0.01
Ages 35 to 44	3:02 (2:39)	2:52 (1:08)	0.30	4:04 (1:14)	4:11 (1:09)	0.20	2.34 (1:17)	2:41 (1:57)	0.20	3:55 (0:57)	3:51 (0:56)	0.22
Ages 45 to 54	2:34 (1:15)	2:35 (1:30)	0.84	3.48 (1.01)	3:51 (1:31)	0.62	2:27 (1:37)	2:27 (0:59)	0.97	3:45 (1.14)	3:50 (1:00)	0.21
Ages 55 to 64	2:34 (1:34)	2:32 (1:21)	0.80	3:26 (1:32)	3:28 (1:06)	0.67	2:35 (1:22)	2:34 (1:19)	0.90	3:34 (1:10)	3:36 (0:58)	0.61
Ages 65 to 74	2:52 (1:16)	3:01 (1:52)	0.12	3:10 (1:17)	3:14 (1:22)	0.44	2:53 (1:13)	3:02 (1:13)	0.05	3:14 (1.15)	3:24 (1:16)	0.02

Table A.3. Distribution of the self-assessed morningness/eveningness in the Finnish adult population from 2007 to 2017 by 10-year age group and sex.

	MEN																										
	2007 (N=3025)								2012 (N=2983)									2017 (N=2297)									
	Definitely evening-type		More evening-type		More morning-type		Definitely Morning-type		Definitely evening-type		More evening-type		More morning-type		Definitely Morning-type		p-value [a]	Definitely evening-type		More evening-type		More morning-type		Definitely Morning-type		p-value [b]	p-value [c]
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%		N	%	N	%	N	%	N	%		
Ages 25 to 34	106	23.3	191	42.0	118	25.9	40	8.8	131	29.7	181	41.0	100	22.7	29	6.6	0.15	76	26.4	111	38.5	77	26.7	24	8.3	0.41	0.73
Ages 35 to 44	86	15.2	199	35.1	202	35.6	80	14.1	120	22.2	192	35.5	152	28.1	77	14.2	0.007	91	26.5	127	37.0	90	26.2	35	10.2	0.19	<0.0001
Ages 45 to 54	65	10.7	179	29.4	225	36.9	140	23.0	88	14.7	206	34.4	190	31.7	115	19.2	0.01	57	14.6	119	30.4	116	29.7	99	25.3	0.14	0.06
Ages 55 to 64	46	6.7	168	24.4	309	44.8	166	24.1	67	10.3	216	33.2	187	28.8	180	27.7	<0.0001	63	11.8	165	30.9	165	30.9	141	26.4	0.63	<0.0001
Ages 65 to 74	48	6.8	146	20.7	287	40.7	224	31.8	83	11.0	232	30.9	249	33.1	188	25.0	<0.0001	62	12.8	133	27.4	150	30.9	141	29.0	0.24	<0.0001
	WOMEN																										
	2007 (N=3495)								2012 (N=3322)									2017 (N=2917)									
	Definitely evening-type		More evening-type		More morning-type		Definitely Morning-type		Definitely evening-type		More evening-type		More morning-type		Definitely Morning-type		p-value [a]	Definitely evening-type		More evening-type		More morning-type		Definitely Morning-type		p-value [b]	p-value [c]
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%		N	%	N	%	N	%	N	%		
Ages 25 to 34	105	16.7	245	39.0	217	34.5	62	9.9	143	24.4	236	40.2	154	26.2	54	9.2	0.001	96	24.6	142	36.4	112	28.7	40	10.3	0.64	0.01
Ages 35 to 44	84	12.5	237	35.2	252	37.4	100	14.9	130	20.4	215	33.7	186	29.2	107	16.8	0.0002	86	19.7	143	32.7	124	28.4	84	19.2	0.79	0.0003
Ages 45 to 54	77	10.5	227	30.9	266	36.2	165	22.4	102	15.1	184	27.2	228	33.7	163	24.1	0.04	68	13.5	175	34.8	138	27.4	122	24.3	0.02	0.01
Ages 55 to 64	78	10.7	183	25.1	272	37.4	195	26.8	119	16.7	196	27.6	215	30.2	181	25.5	0.001	74	12.4	178	29.9	188	31.5	156	26.2	0.18	0.08
Ages 65 to 74	65	8.9	171	23.4	286	39.2	208	28.5	100	14.1	191	26.9	208	29.3	210	29.6	0.0001	94	15.9	177	29.8	160	27.0	162	27.3	0.41	<0.0001

[a] Chi-square between morningness/eveningness frequencies in 2007 and 2012; [b] Chi-square between morningness/eveningness frequencies in 2012 and 2017; [c] Chi-square between morningness/eveningness frequencies in 2007 and 2017.